Close Air Support (CAS) in 2025
"Computer, Lead's in Hot"

A Research Paper
Presented To

Air Force *2025*

by

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2025 is a study designed to comply with a directive from the chief of staff of the Air Force to examine the concepts, capabilities, and technologies the United States will require to remain the dominant air and space force in the future. Presented on 17 June 1996, this report was produced in the Department of Defense school environment of academic freedom and in the interest of advancing concepts related to national defense. The views expressed in this report are those of the authors and do not reflect the official policy or position of the United States Air Force, Department of Defense, or the United States government.

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Preface

The Chief of Staff of the Air Force, Gen Ronald R. Fogleman, directed Air University to conduct a major study on air and space power and concepts applicable to the year 2025 and beyond. This will include examination of innovative systems, new concepts of operations, and the emerging technologies enabling them. The study formally commenced in August 1995 when the students arrived for the Air University 1995-1996 academic year and will conclude in June 1996 with delivery of the final report to the Chief of Staff of the Air Force. The final report will be a logically ordered collection of white papers developed from the innovative concepts and technology abstracts submitted.

Executive Summary

The mission of close air support (CAS) currently exists in every service doctrine and will continue to be required in 2025. Advances in technology will reduce the many shortfalls currently causing concern regarding the CAS mission. In 2025, time-critical applications of airpower and space power in support of troops on the ground will be vastly simplified from the perspective of both the tasker and the attacker. This paper describes the requisite systems and technology needed for aircraft to perform the mission. It does not discuss organizational issues.

Advances in ground-based firepower are expected to proceed at a pace commensurate with technical advances in airpower --perhaps reducing the dependency of ground forces on air support, depending on the coalition elements' technical base. The ability for ground forces to overwhelmingly engage an opponent will always be a goal of the ground commander, and commanders will always plan engagements to optimize usage of their available power. Unforeseen opportunity is frequently a product of warfare. Maintaining the flexibility of tactical forces ensures exploitation of good fortune and rapid response to good fortune's evil twin— bad luck. Regardless of doctrinal issues about the best way to employ airpower, there will always be opportunity to influence the ground battle directly from the air with air-to-ground weapons. The most likely first priority of airpower in future conflicts will be to attain air and space superiority, either concurrently with or immediately following the shock delivered by the initial strategic attack. Attaining air superiority allows a fluid reapportionment of air and space assets. Single-mission tactical aircraft are luxuries not likely to be affordable, given today's evolving fiscal realities. The ability of available air-to-air assets to swing to ground attack will maximize the application of power.

In the year 2025, the inevitable evolution of precision weapons will make every air asset that is capable of ground attack capable of performing CAS. The automated assignment of the ground target coupled with ease of employment and standoff capability will profoundly simplify weapon delivery tactics and defensive system requirements. The addition of onboard and in-flight programming capabilities greatly enhances mission effectiveness. Relative proximity of the target to allied ground troops poised for attack could be the

only discriminator of mission demarcation between CAS, battlefield air interdiction, or even strategic attack. Premission planning and weaponeering time will be slashed. The resultant rapid apportionment flexibility will revolutionize the application of airpower.

Chapter 1

Introduction

Opportunities to make quantum leaps in warfare are rare, but they are upon us today. Due to demonstrated and anticipated advances in technology, the ability to project a survivable weapons delivery platform into heavily defended airspace over a target is rapidly diminishing. The use of standardized standoff weapon systems significantly improves delivery platform survivability. Current and forecast growth in the capabilities of standoff weapons are inadequate to maximize their potential. From the outset, the weapons must be considered as only a part of an airpower system. This white paper discusses the many elements of such a system. It is critical that this entire system be defined as early as possible to allow for concurrent procurement programs for its constituent parts.

In the interest of bounding the problem, only air deliveries of air-to-ground mechanisms near friendly forces are considered here. As the name infers, close air support is the use of airpower in proximity to friendly ground troops to complement their scheme of maneuver. It is apparent that many of the technologies discussed in this paper have surface-to-surface applications. Military objectives and available assets drive the need for target engagement by air firepower in addition to ground-based firepower. The technological evolution in outlying years does not diminish the need for the unique aspects of airpower and space power in the battlefield-- and the deep strikes-- of the future.

Close air support functions as a series of tasks and systems to accomplish the mission. Figure 1-1 shows the sequence of the four attack tasks. These elements are common to many different missions as they are defined today. It is obvious in the development of the recommendations contained in this paper that these systems capabilities may render some mission paradigms obsolescent. The resultant method for applying airpower produces a seamless transition across those paradigms. For academic completeness, there is a

discussion of CAS and its current definitions and methods. It is important to note that CAS is just one of the many ground-attack missions. It is useful to review the following discussions of current capabilities and limitations in this context.

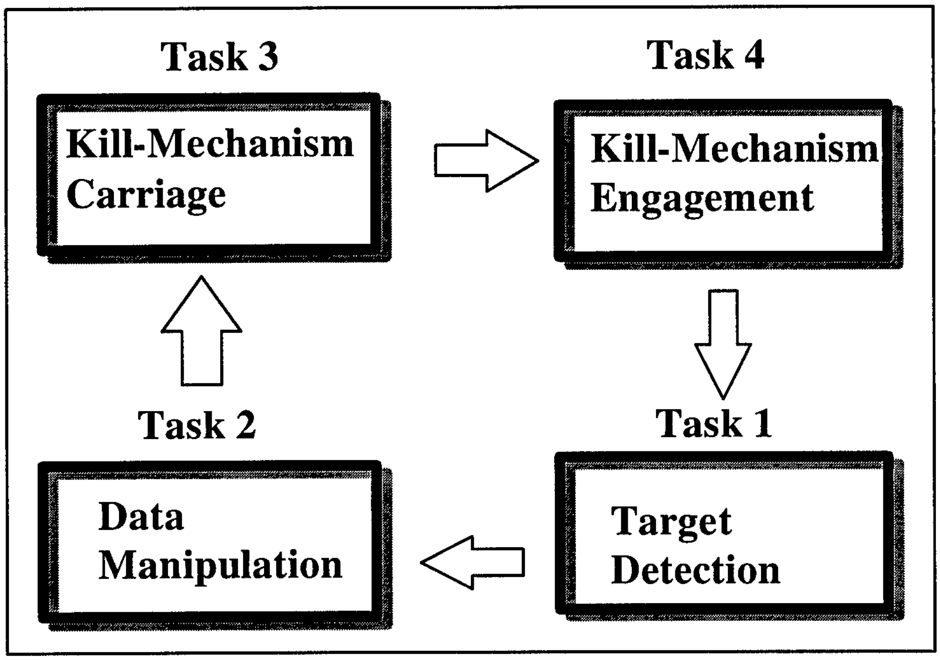

Figure 1-1. Close Air Support Task Loop

Targeting, command, control, communications, computer, and information (C^4I) data, kill mechanism carriage, and engagement are the four tasks associated with CAS. Targeting refers to detection, identification, and tracking. C^4I permits prioritizing and directing our air assets while disseminating needed information to all levels of command. Currently, manned aircraft comprise our kill mechanism carriage. In the future air assets other than manned platforms will comprise the majority of delivery vehicles used in CAS. Kill mechanism engagement refers to weapon assignment, desired effects, initialization, release, acquisition, onboard processing, tracking, and fusing of the payload.

Chapter 2

Current and Required Capabilities

All services define CAS similarly. Appendix A presents the independent service definition and its source. They all stress that CAS is air action against hostile targets in close proximity to friendly forces. To varying degrees they stress that it needs to be timely and, flexible, and that it requires detailed integration with the fire, movement, and location of friendly ground forces. The proximity of friendly forces to targets makes fratricide a real concern. CAS accomplishment requires close integration with ground forces to aid their scheme of maneuver. It is important to realize that CAS is *not* independent air action against the enemy where there are no friendly forces. Missions flown in Bosnia during 1995, for example, should not be classified as CAS.

Close Air Support Description

Today's close air support mission requires a one-on-one relationship between the delivery platform aircraft and the ground tactical representative to employ weapons in close proximity to friendly forces. To produce this relationship in a timely and, efficient manner requires a complex command and control network. Appendix B has a more in-depth discussion of the current means for conducting CAS. CAS planners and operators must have a thorough understanding of joint and service operating procedures. In addition, they must understand service communication requirements, delivery platform capabilities, and weapon effects. Significant limitations to CAS effectiveness (e.g. target identification, the threat of fratricide, and the operating environment) prevent full exploitation of the capabilities offered by airpower on the battlefield. Appendix C describes these limitations more fully.

Close Air Support Issues

The CAS debate will be entering its 80th year in 2025. The Army and the Air Force disagree over several issues about how to conduct CAS. Mission allocation priorities, target tactics, timeliness, night and weather capabilities-- all constrain CAS effectiveness. Proposed service-specific solutions are the source of this rift. The Army feels that Air Force allocation and acquisition priorities neglect CAS in favor of air superiority, interdiction, and strategic strike.[1] However, the realities of 2025's battlefield will force an accommodation between the two sides. The Army will acknowledge that CAS aircraft cannot loiter inside the enemy's antiaircraft envelope and expect to survive. The lethality of 2025 antiaircraft weapons will place greater demands on aircraft operating around enemy troops. After action reports on Desert Storm showed that CAS aircraft (A-10s and AV-8Bs) suffered the highest number of combat losses.[2] Uninhabited aerial vehicles (UAVs) can currently loiter over a battlefield to provide reconnaissance data to collection agencies. These vehicles are readily adaptable for ground attack missions, especially when a significant antiaircraft threat exists. This fulfills the Army's need for ubiquitous airpower presence.

Army doctrine demands high tempo 24-hour-a-day, all-weather operations. Current CAS shortfalls in poor weather and night conditions capability make Army planners reluctant to plan operations where Air Force firepower integration is essential to mission success. Consequently, the Army has often excluded CAS from their scheme of maneuver. These environmental limitations to CAS will be overcome by 2025, thus making CAS more dependable.

Currently the Army is concerned that "immediate response" CAS is not responsive enough to the Army field commander and his scheme of maneuver.[3] The Army desires on-call, near instantaneous assets, even if that means holding back those assets from accomplishing multiple missions. The Air Force wants to take full advantage of the high sortie rate of combat aircraft and not hold back assets on the chance they might be needed.

Several improvements by 2025 will serve to mitigate CAS shortfalls. Weapons will be more versatile; the same weapon will be able to reconfigure to fragment for soft targets or penetrate for hard targets. Consequently, mission tasking will be less restricted by aircraft weapons load. Weapons will have greater ranges and stand-off capability. All surface-attacking aircraft will be capable of precision weapons delivery

in weather or at night and will therefore be CAS-capable. Ground commanders and aircrews will have access to the information from a common network that will electronically model the battlefield. The next chapter describes that network.

Notes

[1] Raoul Archambault and Thomas M. Dean, *Ending the Close Air Support Controversy*, Newport, R I (21 June 1991), 8-11.

[2] John T. Correl, ed., "More Data From Desert Storm," *Air Force Magazine* 79, no. 1 (January 1996): 62-66.

[3] Archambault, 14.

Chapter 3

System Description

In 2025, a ground force element nominates targets via the battlenet without regard to how they will be attacked. The ground force elements is concerned with effect and criticality. The battlenet is a system of systems that collects data from multiple sources, fuses the data, turns data into information, and continuously updates battlespace situational awareness for all users. Furthermore, it provides a comprehensive communications network for the commanders involved in combat to synergistically direct the fight as well as a means for the war fighters to execute and report.

As the battle unfolds, enemy units confronting the ground commander cause direct conflict with the planned scheme of maneuver. Other units not yet on the scene may also threaten the plan. The commander will have a display (a miniature 3D model) of the battlespace (provided by the battlenet). The commander may customize the battlenet display to present only relevant information and forces. Via this battlenet, the ground commander designates targets for destruction, containment, or immobilization, and the timing of such effects. Artificial intelligence (AI) imbedded in the battlenet, as programmed by cognizant authority, will inventory available friendly forces and task weapons systems to engage the enemy within microseconds. The battlenet component onboard a manned platform receives the tasking, acknowledges the assignment, adds the targets to a customized display of the battlespace, and recommends a course of action to the operator. If no friendly system is available at the required time, the battlenet presents various options to the ground commander. It may suggest changing the timing of the attack, the desired effect, retasking another assigned unit, or relaying a request for additional force to the next higher commander on the battlenet. Higher levels of command may hold forces in reserve to answer these requests. Human oversight is available at all levels to provide a robust backup system and to ensure that artificial intelligence and scheme of maneuver remain in

concert. The battlenet will be used by all levels of command and operations, from the commander in chief (CINC) monitoring the theater campaign down to the engaged tank commander. The tank commander uses the battlenet to request additional targets or for assistance in disposing with the present batch.

The nominator of the target may not be physically in the area of operations. In fact, the tasking order may direct CAS not by sortie but by weapon and vulnerability time over a region. This, combined with all-weather weapons, will make CAS constantly available to the battlespace commander. An aircraft on an interdiction mission may be tasked by the battlenet to deliver some of its weapons in a CAS scenario, requiring the platform to ingress over a certain area at a specified time to expend the selected weapons enroute to the interdiction target. Weapons or sorties could be shifted to other missions by the battlenet when it determined that the weapons were no longer needed for CAS. In fact, any aircraft transiting near a ground unit could be tasked by the battlenet for any or all of its weapons to aid in an engagement. The battlenet provides a means for shifting aircraft to higher priority targets at any time. This would be normal, and would be a part of routine training. Human operators coupled with battlenet logic decide whether the new target has high enough priority to warrant diverting or delaying a platform.

Background and Assumptions

In the world of 2025, the Air Force operates at considerable distance from the United States over periods ranging from weeks to months.[1] High-tempo operations will be conducted around the clock, unaffected by weather conditions. With the formation of new nations and changes in the world order, the United States will not know when or where the next conflict may appear, who will be fighting, or whether they are recognized government forces, nongovernmental organizations, or insurgent groups.[2] Technological advances in all fields will provide a vast array of improvements in materials, computing power, sensors, and weapons. One downside to these technological improvements is that they will be available to almost everyone interested in obtaining them. It is reasonable to assume that today's emphasis on reduced costs, reduced collateral damage, and short-duration involvement will continue in the future. A CAS system in the future (fig. 3-1) must be able to cover large distances and be able to loiter well away from the target area, yet be able to penetrate a highly defended threat zone consisting of surface-to-air missiles, directed energy

weapons, stealthy aircraft, and attack from space.[3] In addition, the system must be able to support operations in environments from thick jungle to urban areas against all types of adversaries, ranging from heavily armored, fast-moving shock forces to crowds in the heart of a major city. Two issues central to CAS--proximity to friendly forces and the rapid delivery of weapons-- will not change. Forces will still need to "close" with each other to achieve a tactical decision. Closing with each other is obviously a relative term, since weapons of the future may have tactical ranges well beyond those of today. The effectiveness of future weapons requires rapid response from our systems to prevent high casualty rates.

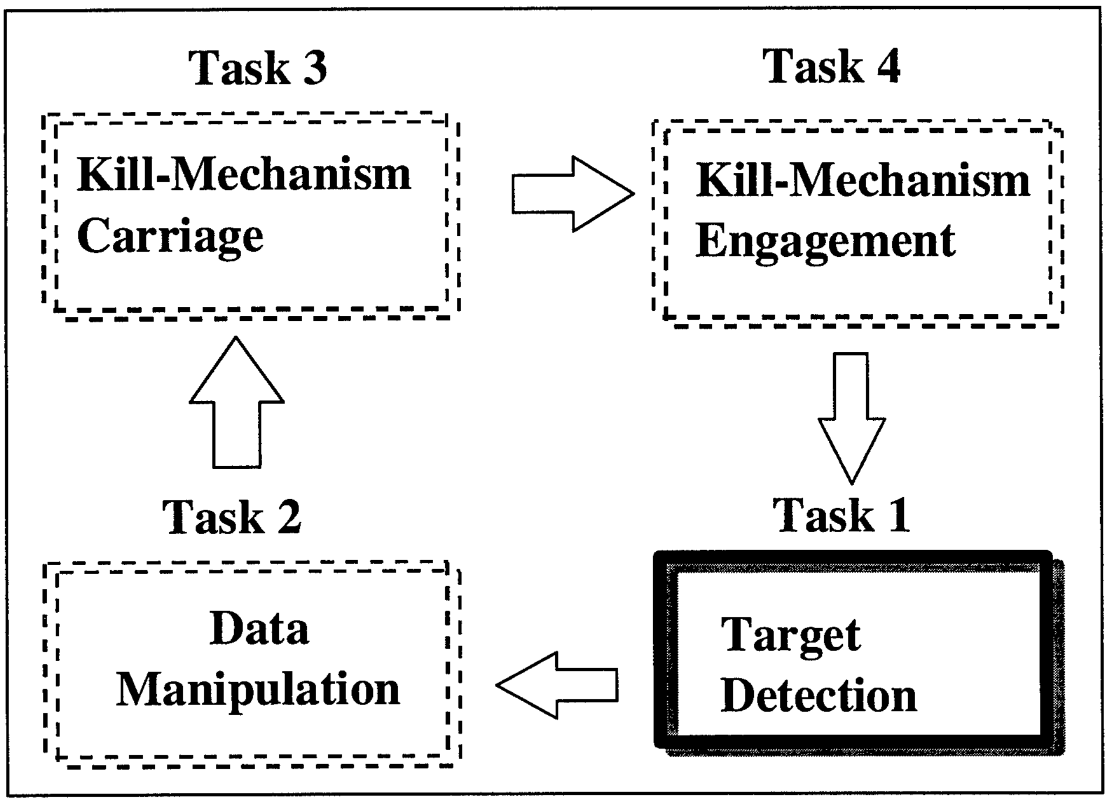

Figure 3-1. Target Detection Tasking in CAS Loop

Target Detection

A major limitation of CAS today is the requirement for the forward deployed spotters to visually sight enemy vehicles or troops before bringing in air support. "Because smaller units will be capable of massing decisive effects on future battlefields, there will be a greater need in the 21st century for our forces to

become less detectable to the enemy" and, conversely, to make the enemy far less opaque to us.[4] Human observers on the battlefield become less and less effective as forces become smaller, more maneuverable, and lethal. Current intelligence outputs give the ground commander the general location of an enemy force, but not in near-real-time and not with great accuracy, especially if the targets are in motion. Battlespace commanders in the future must have near-real-time enemy dispositions, movements, and intent if at all possible. Our commanders must have continuous knowledge of the presence of individual vehicles prior to their arrival in the battlespace commanders' area of influence until they are in close contact with friendly forces. Uninterrupted coverage of target vehicles and personnel in all types of weather, on any terrain, or in an urban environment, should be the minimum level of performance in 2025. Force XXI's concept of operations dovetails with this philosophy and states that our required capabilities hinge on leveraging information-linked technologies, particularly sensor fusion, robotics, fuzzy logic guidance, and control.[5] Following a preliminary operational analysis on CAS as a system, the following criteria were identified as the most important in target detection and tracking:

1. target location accuracy; less than 10 meters preferred
2. environmental availability; detection 24 hours a day in all weather and terrain
3. target location update; situation dependent 0 to 6 hours[6]

In order to satisfy these and other requirements the United States must develop new sensor technology. One candidate system utilizes space platforms as the primary means of surveillance. However, a system based entirely on satellites poses some formidable problems. Orbital distances create signal attenuation, loiter time, area coverage, and power supply problems for satellites. Elements of the radar equation exact great concessions from a space-based system in terms of power requirements, signal-to-noise, and resolution.[7] Very large structures will be required to generate the power required by these systems, a fact which negates the desired design feasibility, cost savings, hardness, and maneuverability desired from orbital platforms. "The next generation of American spy satellites should be able to provide virtually continuous 24-hour coverage of a battlefield anywhere in the world. Even further into the future, they may be able to distinguish friend from foe by 'licking' the battlefield with a laser so that commanders can follow the movements of their own forces as well those of the enemy."[8] This type of system could be expensive, and commanders would likely use these satellites for higher priority missions.

Upgrading existing airborne platforms such as joint surveillance target attack radar system (JSTARS) and the airborne warning and control system (AWACS) will provide some improved capabilities over the next 10 to 15 years. However, the relatively small area coverage, operational inefficiencies, high operating costs, vulnerability, and limited number of these aircraft will severely hamper their operations and reduce their usefulness. The uninhabited reconnaissance aerial vehicle (URAV) proposed in *New World Vistas* appears to be a cost-effective solution when employed either as an independent system or in conjunction with other airborne and spaceborne platforms. URAVs can be outfitted with a wide variety of multispectral sensing equipment-- such as synthetic aperture radar (SAR), light detection and ranging (LIDAR), optical viewers, or laser radar-- and then deployed to loiter at very high altitudes for extended periods without refueling. Already a current electro-optical system suitable for installation on a fighter-sized platform produces "tactically significant imagery" up to 60 miles away from the target.[9] URAVs working in conjunction with manned platforms and satellites could easily provide continuous and detailed coverage of the area of interest.

URAVs can work cooperatively with satellite constellations by projecting high-power radio frequency (RF) beams over the area of interest. The satellites receive reflected signals from targets near [on] the earth to form a distributed bistatic synthetic aperture radar system (fig. 3-2). Clutter rejection is improved because of the varying reflection angles to different satellites. Moving and fixed targets can be detected with high resolution as the result of the long baseline between satellites. This arrangement limits the number of expensive spaceborne transmitters by reducing coverage to a specific area of interest.[10]

This mixture of satellites and URAVs produces resolutions under 10 meters and continuous coverage over a given area of interest. Drawbacks to this system are the complexity and susceptibility of URAVs to attack or malfunction, the requirement to have multiple aircraft on call, and the possibility of leaving an area unmonitored.

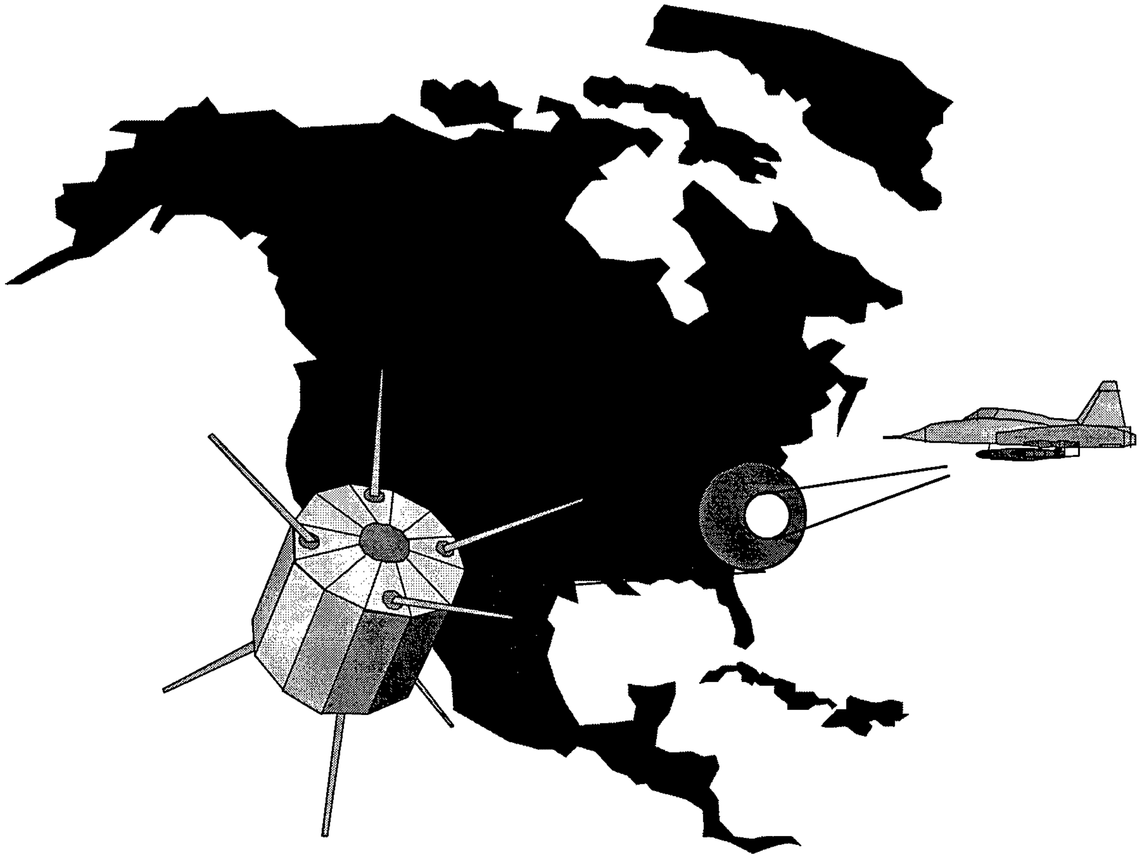

Figure 3-2. BiStatic Target Detection

Remote sensing in synchronization with or in the absence of airborne or space platforms utilizes surface arrays of small camouflaged disposable sensors capable of transmitting data to collection platforms.[11] Sensors can exploit the full electromagnetic spectrum, detect forms of mechanical energy such as seismic or acoustic signals, and physically analyze diverse sets of chemical and biological components.[12] Artillery, missiles, or airborne platforms dispense the remote sensors, automatically recording their locations. Signature data transmitted by the sensors to the battlenet become identified targets with speeds and vectors. Active detection devices such as directed-energy transmitters may alert the targets of the presence of sensors, therefore the commander must have the option of passive sensing if targeting effectiveness is adequate.

We must develop a network of ground-based sensors, high-altitude unmanned platforms, and surveillance satellites as recommended by the *New World Vistas* study.[13] The battlenet must then provide this intelligence to all levels of command with continuous updates including near-real-time battle damage assessments.

Concept of Operations. Locating and tracking a fast-moving vehicle made of lightweight nonmetallic materials powered by a quiet, cool engine may be very difficult. This problem is made even more difficult if the vehicle has radar/IR low-observable technology and onboard countermeasures capable of deceiving radar or laser tracking systems. According to the Army, vehicles on the future battlefields will have these characteristics.[14]

Satellites with multispectral sensor suites will locate enemy forces well before their probable contact with friendly units. A battlenet collects data from multiple sources, such as signals, imagery, emissions intelligence, and remote sensor inputs, then fuses the data and continuously updates the battlespace picture. Cycle time between updates depends on the orbit or the number of satellites in the net. Air-breathing UAVs supplement intelligence collection by providing updates to enemy movement over a wide area or focusing on a particularly difficult tracking problem. The battlenet that is providing information to the commander decides when to increase the frequency of observations and adjusts orbital flyovers or activates air-breathing platforms as required to maintain accurate target locations. When commanders, at any level, need more detailed information, they direct the battlenet to provide it and the battlenet chooses the method. A robust system depends on multispectral sensing from each sensing platform in order to accommodate different target types and ambient conditions. As friendly and enemy forces close on each other, cycle time for system updates shrinks to zero, requiring a continuous flow of data into the battlenet. Potentially large target densities found in armored battles or urban crowd control operations dictate that the battlenet be able to discriminate individual vehicles or personnel from among larger target sets. UAVs supplement battlespace coverage at this point, and the battlenet controls their actions. The sensor suite on manned vehicles automatically selects the proper sensor or combination of sensors to compensate for target type, terrain, light, and weather, and then displays the image via a pilot's helmet-mounted cueing system while passing the information to the battlenet. In an autonomous mode the system could find targets, identify them, and then launch weapons without human intervention.

A detection system must be capable of thwarting countermeasures created by target systems. Visual spoofing, such as holographic displays, would fail to pass a multispectral imaging process as they would not create thermal, magnetic, electromagnetic, or acoustic returns.[15] False thermal sources also fail to pass through multispectral gates and discriminators. Artificial intelligence (AI) queries the system to find if target

motion or activity matches known behavior and checks for countermeasure activity. Adaptive learning by the battlenet compensates for new countermeasures fielded by an enemy by adapting the sensor suite without human intervention.

Target Identification (Combat Identification)

Future weapons systems must possess the capability to operate cooperatively with non-US forces in stand-off engagements using smart weapons while preventing collateral damage from friendly fire.[16] The United States will continue to be a major exporter of weapons to other countries; therefore it is reasonable to expect future enemies to come equipped with equipment similar to our own. automatic target recognition (ATR) technology must progress to the point where accuracy, reliability, and unambiguous target recognition allow application of lethal force with nearly 100 percent assurance of target identification.[17]

The primary characteristics required of a combat identification (CID) system are accuracy, reliability, and security. The desired system must exhibit close to 100 percent accuracy, reliability under all operating conditions, and security in order to prevent the enemy from mimicking or denying us the identification capability. As a corollary to accuracy, the CID system must be robust enough to utilize any identification systems of civilian police forces, coalition members, or allied nations. Allied forces may present problems to our systems since equipment may not be standardized or even fielded by the respective nations. Coalitions, by their ad hoc nature, present several complications (e.g., language barriers, dissimilar equipment, and limited time) to us in distributing our system for use during rapidly developing scenarios.

For this discussion, CID systems fall into two main categories: active-cooperative and passive. An active-cooperative system requires a transponder affixed to the vehicle or person to transmit a response to an interrogation; much like the battlefield combat identification system (BCIS) currently undergoing testing by the Army. The BCIS actively queries and responds to similarly equipped vehicles in all weather conditions with up to 99 percent accuracy.[18] In the future, responses to interrogation should be multispectral; utilizing acoustics, IR, visual bands, RF, millimeter wave, and laser beams. Active systems have several problems associated with them. One is reliability. Unless the system is 100 percent reliable possibilities, exist for fratricide in combat. Antennas and other external devices (the BCIS uses an externally mounted transponder)

may be blown off during combat, rendering the system useless. Another problem is security. If an enemy can read, jam, or duplicate the incoming or outgoing signals, the system's effectiveness becomes severely degraded. If the signals are not of a low probability of intercept (LPI) nature an enemy is likely to be able to localize emission sources and target them. It is also reasonable to expect that some of our systems will fall into enemy hands, therefore our system must be reprogrammable. A different type of active system does not require interrogations but periodically transmits required information such as identity and status in the blind. This information "strobing" would have to be spectrally unique to prevent detection, but could simplify the overall system and allow one half of the ID equation to remain passive.

Semipassive systems do not utilize transponders or transmitters to reply to interrogations. Instead an interrogator reads the identity from a tag or label of some type on the vehicle of person. For example:

> Spacecast 2020 suggested using techniques that it likens to 'licking' and 'tasting' to identify objects on the ground. The licking would be done by a laser beam fired from a satellite which would be equipped with sensors that would 'taste' the spectrum of the radiation reflected back from the target. By comparing this with a database of know tastes it would be possible to identify an object. Friendly tanks and aircraft could be coated with a chemical that produces a characteristic spectrum when excited by energy of a certain frequency or other characteristic.[19]

A totally passive system requires the use of naturally occurring emanations such as acoustic, thermal, or RF energy from a target. Another type of system scans for characteristic signals reflected from offboard illumination of the target (visual light, distortion of magnetic fields, or bistatic imaging systems). Computerized pattern recognition is a current and evolving technology.

In all likelihood, in order to achieve near 100 percent accuracy, the CID system of 2025 needs the capability to both actively and passively discriminate enemy from friendly and combatant from non combatant.

Concept of Operations. In 2025, friendly troops enter the battlespace with their personal identifiers.[20] The identification mechanisms could be in the form of microchips worn by or imbedded in the soldiers and chemical implants injected into the body or grown externally.[21] Microchips must be capable of transmitting a response to interrogations in an active mode. In a passive mode, the presence of a chip containing the correct code detected by a sensor acknowledges identification. Chemical or defense nuclear agency (DNA) sniffers detect the desired chemical in a soldier or the existence of a particular organic material grown on the

soldier's body. The same principle could be applied to vehicles. A molecular patch of material imbedded in the vehicle provides a passive method of ascertaining its identity. A variety of multispectral transponders provide active recognition to battlenet queries. Enemy troops and vehicles may be identified by default. If the battlenet knows the locations of every friendly troop or vehicle and can identify noncombatants, then anything else detected is declared hostile unless designated by the battlespace commander.

Sensors locating objects in the battlespace have the ability to identify the object if directed by the battlenet. One type of system utilizes pattern recognition logic to pick out pieces of data coming from sensors and comparing the data to previously stored signatures to identify enemy troop formations and even individual vehicles. If information needed by the system is not available, the system directs other platforms or sensor types to reconnoiter the area in question.[22] An active or passive system could identify friendlies by reading a label attached to an object via numerous methods. As the battlenet sensors detect each target in the battlespace, they apply a physical label to the target. For example, a particle beam imprints coded information on the exterior of specially painted vehicles or irradiates the clothing of exposed personnel. Labels placed on targets could be magnetic, optical, or electronic, and can be sized down to the molecular level. The label contains data that includes the type of target, date time group, and military unit controlling the vehicle or person.

The system must be robust enough to utilize the identification systems of allied forces during coalition operations. Sensors would be required to interrogate an unknown transponder, analyze the response, and determine if the response came from a friendly system or a designated hostile system. If the interrogator receives a response that does not correspond to known friendly systems or fails to receive a response at all, the interrogator activates a separate series of identification methods involving discriminators such as material composition, acoustic, electromagnetic, or vibration signatures. For situations involving a mixture of hostile forces and noncombatants in an environment where no external evidence distinguishes the two (a riot or urban disturbance for example), the system may need only distinguish between friendly "tagged" personnel and others. Current electro-optical sensors can discriminate individuals for positive identification at ranges up to three miles; by 2025, it is reasonable to postulate ranges an order of magnitude farther away.[23] Pattern recognition logic could assist in threat determination, based on discriminators such as

vehicle type, color, and motion, or note whether personnel are carrying weapons, moving in a tactical manner, etc.

The battlenet fuses information from a wide variety of sources to bring the confidence factor of the target identity to near 100 percent. The battlenet transmits its confidence factor with the target identity to commanders, thus providing them with crucial engagement data.

Target Tracking

Target tracking is handled as a category, separate from detection. A complete CAS system must be capable of not only finding and identifying objects in the battle space but keeping track of them as well. Tracking systems capable of flexible update cycles maintain contact with designated targets throughout extensive maneuvering during close contact with friendly forces. As with detection, robust tracking systems utilize a mixture of space-based platforms, UAVs, and ground sensors to accomplish the mission.

Concept of Operations. Space-based platforms, URAVs, or remote sensors identify an enemy force in the battlespace commander's area of interest. Sensors identify the number and type of targets as well as the status of the force. A designator mechanism physically brands each target by placing a magnetic, laser, or other detectable code on the object. Various identification mechanisms read this tag and update the battlenet with target location. If a hand-off from the original detection platform to subsequent sensors occurs, the follow-on sensors read the target codes and feed current locations and vectors into the battlenet, thus updating the system. Targets not showing up during repeated update cycles cause the battlenet to provide additional scrutiny from search sensors as the system attempts to relocate the objects. Remote ground sensors providing target information to the battlenet may be equipped to read the identification codes already placed on each target, place a designator, or merely pass existent data to the battlenet. Weapon guidance mechanisms would have the capability to acquire and track these specific identity codes. Tactical platforms capable of continuous real-time target tracking interface with the battlenet to maintain the picture; thus, the battlespace commander or anyone requiring immediate target locations may access the information.[24] Multiple platforms managed by the battlenet follow selective target tracking, lists to preclude or provide selective redundant

tracking thereby giving the battlenet a capability to resolve conflicts caused by multiple ground observers locating and designating the same target.

Depending on the level of information required, the battlenet provides each user a display of all or a portion of the battlespace to include friendly and enemy locations as well as terrain features, target types, and target status (destroyed, pending destruction, untargeted). Display methods vary from helmet-mounted displays to laptop sized units in the hands of soldiers to large, room-sized units where commanders can move or see anywhere on a "virtual" battlefield.[25] For manned aircraft, the pilots' virtual visor presents the picture outside his cockpit in any direction. The picture includes target location, aircraft parameters, threat locations, weapons status, and friendly locations.

The battlespace commander authorizes the battlenet to service a target in whatever manner desired. Since the battlenet maintains continuously updated target files, the system chooses a method, weapon, and platform. It then launches and, if necessary guides the weapon to the target. Battle damage and resulting target effectiveness are displayed as soon as the battlenet processes the data.

Command, Control, Communications, Computers, and Information

The success of future CAS hinges on effective command and control (task 2 of fig. 3-1). This integrated system must appear seamless to ground units and to the joint aviation targeting process. According to out year projections of doctrinal concepts (*Sea Dragon* and *Force XXI),* United States Marine Corps, (USMC) and United States of America (USA) operational doctrine will diminish the importance of linear forward line of troops and fire support coordination Line concepts by 2025. Both services envision a greatly expanded amorphous and opportunistic battlefield, with small units operating in great breadth and depth supported by indirect fire. It is a battlefield with no front, rear or flank, where detection results in engagement. Multiple sources, ranging from forward-deployed ground forces to battlespace commanders thousands of miles from the battlefield, input indirect fire requests to the battlenet. Target input will be to battlenet by data burst or similar low-signature transmission. Commanders, with significant assistance from the battlenet, conduct target analysis for appropriateness, deconfliction, validity, and availability of aviation assets. When the battlenet receives instructions to engage a target, the battlenet assigns a delivery platform and transmits

necessary information directly into the fire control system. Weapon and navigation programming are automatically accomplished while the platform proceeds to release points. If the situation dictates, the ground commander may direct the weapons platform to contact a ground or airborne controller for "danger close" or degraded deliveries. Partial failures in the battlenet allow graceful degradation to 1995 doctrinal-style CAS. The battlenet also allows multiple levels of interoperability with coalition partners.

Battlenet System

Human input to the battlenet comes from a variety of equipment (fig. 3-3). All sources, whether they are laptop computers or handheld radios, are secure and jam-resistant. Operators gain access to the battlenet after providing identification that the battlenet recognizes. Key cards and code words are simple forms of identification that are easily distributed to operators. Fingerprint recognition or voice matching are more complicated methods of identification that can be used to gain access to the battlenet. Voice-to-data converters provide unprecedented freedom to the operator by allowing direct voice contact with battlenet computers. Built-in redundancy against single point cataclysmic failure permits graceful system-wide degradation and partially shields operators from the effects of enemy attacks. Filtering data and automatic situation updating of the dynamic 2025 battlefield present two major challenges to a battlenet system. Various command levels will have different available information and display presentations are possible. System designers must analyze the vulnerability and requirements. Virtual reality, holographic, and multifunction personal display device efficiency of centralized versus decentralized processing systems.

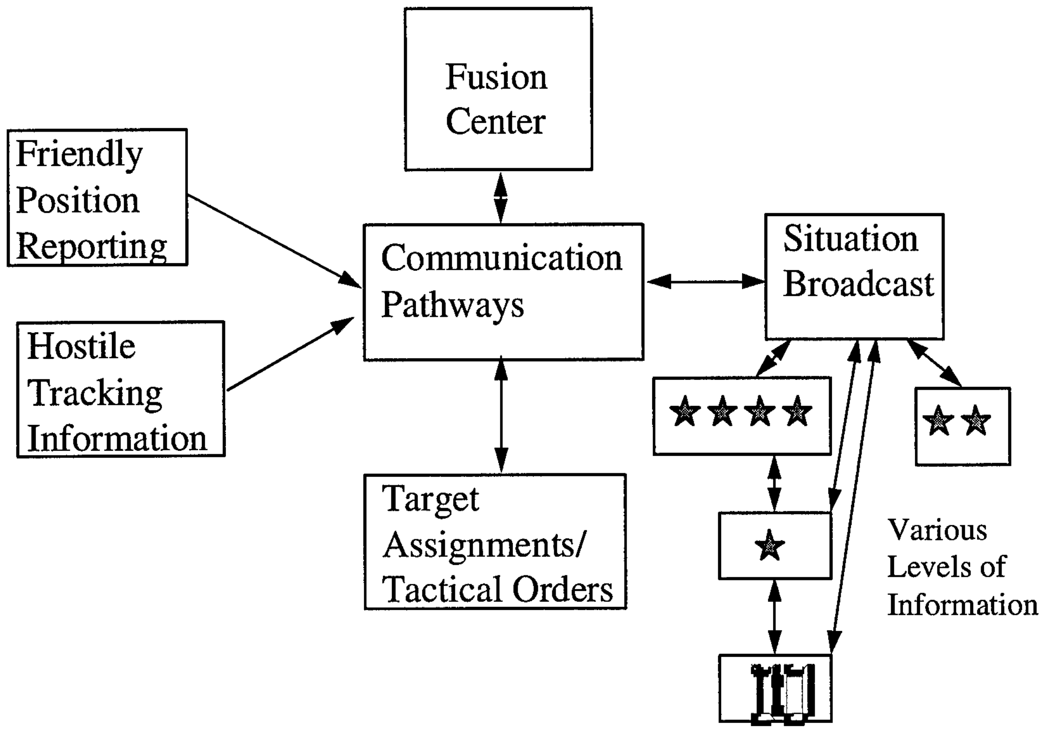

Figure 3-3. C⁴I Network

A horizontal command and coordination network integrating aviation and ground operations ensures quick response to CAS-type missions. The elimination of intermediate decision levels lessens delays caused by administration and processing procedures. The transparent injection of CAS missions into other sorties further enhances CAS timeliness.

Concept of Operations. Input from the sensor network builds a situation map in both digital and visual formats. The battlenet updates friendly, neutral, and enemy locations to the level of detail required to keep pace with their movement through the battlespace. Various levels of command have access to varying degrees of information, dependent on need and security requirements. The battlespace commander engages enemy units as required to accomplish task force missions. As enemy units move (or in a worst case "pop up") closer to friendly ground units, a variety of sources place CAS requests into the battlenet. The battlenet displays the information to the battlespace commander and a decision to engage follows. All levels of command, from the battlespace commander down to the ground tactical leader, receive a regularly updated

target status from initial detection and engagement to post mission battle damage assessment (BDA). Mission specifics such as location, description, time-on-target (TOT), routing, and target layout are sent to the delivery platform. Computers produce an optimal route to the target, taking into account terrain, threats, and a host of other factors. The battlespace commander possesses the ability to amend the mission until weapons impact. The command hierarchy establishes an authorization priority to preclude conflicting commands. This allows for late changes or mission aborts in case of unforeseen deconfliction problems. A capability to introduce last minute changes to CAS missions, or even weapon trajectories, reduces the potential for air-to-ground fratricide incidents. After weapon impact, the battlenet conducts multisensor BDA to determine mission success and reattack requirements.

Kill-Mechanism Carriage

The "battleplane" of Douhet, a stealthy high-altitude, high-speed bomber that can shoot down incoming missiles, reflect high-energy weapons, rain destruction upon the enemy, and remain affordable probably will not exist. Thirty years is generally insufficient time to procure another new-technology bomber. Current trends in aircraft acquisition time and cost-combined with increased congressional oversight, legal battles, and smaller budgets, virtually guarantee that most of the airframes flying today will still be flying in 2025. Note that the A-6, B-52, C-130, and C-141 flew during Vietnam and are still flying today. Thirty years will elapse from the time the F-15 became operational until its replacement, the F-22, is operational-- assuming no further delays. President Jimmy Carter canceled the B-1 program in favor of a stealth bomber almost 20 years ago. However, a fleet of fully operational B-2 stealth bombers, the block 30s, has not been completely fielded. Lost investment and legal battles over the cancellation of the A-12 program and the Supercollider serve as examples for more oversight. Bureaucratic requirements and approvals result in less risk-taking, which ultimately further slows a lethargic acquisition process. Shrinking defense budgets offer fewer incentives for contractors to champion new products. The consequence to the war fighter is older airframes with more upgrades and improvements. The year 2025 may yet see an F-16 block 80, F-15F, or a B-2 block 40 aircraft. Forecasts show the venerable B-52 to remain in service until 2040.[26] Budgetary constraints may find the United States purchasing only manned aircraft that are currently past the demonstration and validation

phase (e.g., the F-22, V-22, and possibly the Joint Strike Fighter). New-technology demonstrator aircraft will also be in existence in the test environment, but not in operational units.

Demands on aircraft systems remaining in the 2025 inventory include greater aircrew situational awareness, augmented countermeasures, better threat identification, greater stand-off range, and improved weapons performance. Improvements in miniaturization and processing power will open new opportunities for communications, information processing, weapons, and UAVs. Future uninhabited combat aerial vehicle's (UCAV), viewed as cheaper alternatives to manned aircraft, are expected to significantly exceed today's capabilities. However, UCAV procurement faces some of the same acquisition challenges that manned aircraft face. Hopefully, the promise of an order of magnitude leap in performance over current manned aircraft with the prospect of affordable costs will spur the development of UCAVs.[27]

By the year 2025 astro-trackers, terrain matching systems, and improved inertial navigation systems (INSs) will offer relief from the growing dependence on the global positioning system (GPS) yet preserve the navigation accuracy demanded by sophisticated weapon systems. Aircraft navigation computers will store detailed maps of the planet's surface, the location of minute gravity anomalies, and an electronic order of battle. A highly accurate navigation system and a detailed map of the planet provide the means for aircraft to fly nap of the earth passively. Future advances in artificial intelligence and cockpit enhancements permit a significant workload reduction, thus enabling aircrews to devote more time to avoiding the threat and attacking the targets. Greater tactical flexibility will be achieved through better three-dimensional displays of the local combat environment, enemy weapons engagement zones, weapon ranges, and the disposition of forces.

Improved communications and computer capability with a preponderance of smart stand-off weapons give all surface attack aircraft, as well as aircraft not necessarily considered tactical, the capability to conduct close air support. Notable improvements in weapon performance create a mission for essentially an airborne truck. The truck, a UCAV, helicopter, F-22, or B-52, simply hauls weapons to a launch point and initiates a mass attack or an individual weapon launch on demand.

Tactical delivery platforms equipped to carry iron bombs and a gun still have a place in 2025, possibly for no other reason than the fact that these weapons are so numerous, reliable, and cheap. At the high end of the technology spectrum, directed-energy weapons installed on 2025 gunships (progeny of the AC-

130U) offer the possibility of surgical destruction on a variety of targets. As replacement costs for aircraft grow prohibitive, more will be spent on survivability, resulting in an expanding spiral. Ultimately, even strategic bombers need the advantage of being able to shoot back when a venerable but upgraded MiG-21 serendipitously stumbles into a successful intercept.

Many of the same measures used today to evaluate CAS aircraft carry over into 2025. Parameters reflecting superior performance may not be the one's we recognize today. However, aircraft range, speed, weapons capacity, and delivery precision are easily measurable. These characteristics initially answer the question, "Can the aircraft do the job?" Weapon system lethality, aircraft survivability, vulnerability, hardness, and stealthiness form the core characteristics used to address compatibility between aircraft and mission. These measurements, although more important than simple performance factors, are much more difficult to assess quantitatively. Cost, maintainability, and reliability will still be important discriminators, and they will remain under the watchful eyes of the military, Congress, and the media. In the future, aircraft value will be highly leveraged against its capacity to accommodate multiple roles. Single-mission aircraft become a luxury too expensive to be affordable. Flying qualities, critical in the past to aircraft selection, will be less important during initial assessment and selection. Software-driven flight control systems, such as in the F-16, C-17, and B-2, permit operators to rapidly modify aircraft flight characteristics.

Information is the high ground of the twenty-first century.[28] Consequently, new critical measures of merit for aircraft will be pilot vehicle interface, human factors, controls, displays, and data fusion. Successful CAS requires fusing data, processing data into information, and timely display of useful information to the aircrew. The absence of quality, easy-to-use controls and displays increases aircrew workload to the point that CAS becomes impossible; the aircraft truly becomes all Mach and no vector. Placing a premium on operational flexibility and lowering aircrew workload during cockpit upgrades results in maximum aircrew effectiveness. Designing from scratch and using automation as an end instead of means are formulas for disappointment-- or at the least, very expensive programs. Aircraft test programs, such as the B-2, have rediscovered that failure to transfer the lessons learned from other aircraft such as the F-16C, F-18, F-15E or F-117, and building automated systems around a rigid, single-focused mission-creates an architecture that is labor-intensive and has little operational flexibility.[29] Flexibility is the foundation of CAS and airpower. An aircraft with no flexibility has no utility in accomplishing the CAS mission. By 2025,

fiscal and operational realities will drive the requirement that all strike aircraft, including heavy bombers, be capable of supporting CAS.

Kill-Mechanism Engagement

This section addresses how munitions apply to the 2025 CAS mission(task 4 of fig. 3-1). First, it describes CAS munition characteristics, current weapons, and development trends. Second, it describes future weapon developments and enabling technology required the CAS mission. Finally, this section addresses possible munition countermeasures and counter-countermeasures.

Weapon performance in 2025 will require the same core capabilities as in 1996. Currently, CAS weapons must affect enemy battlefield targets in ways defined as both desirable and advantageous to friendly ground troops. Traditionally, the military limits this association to target destruction. Friendly forces do not always require, or even desire, the complete destruction of an enemy target. This holds true for the entire continuum of targets, from individual soldiers to massed tank formations.

The Viet Cong, for example, found it sometimes beneficial to severely wound or maim US troops rather than kill them outright. Wounding a soldier had the added benefit of degrading his unit's effectiveness by saddling his fellow soldiers with his protection and care until his evacuation. In another example, we can destroy the mission effectiveness of a radar-guided surface-to-air missile (SAM) through electronic jamming of acquisition or tracking elements, as opposed to physical destruction with a bomb. Additionally, jamming may be more cost-effective and less risky than attempting a hard kill. We, therefore, conclude that target characteristics and ground force needs will drive the requirements of CAS weapons in 2025. As previously stated, this does not always equate to target destruction.

Keeping the above discussion in mind, we now address some CAS weapon characteristics that will be required in the next 30 years. First, weapons must produce the desired effect on the target. This characteristic can span the entire range, from vaporizing targets to merely rendering them ineffective for certain periods. Second, CAS weapons of 2025 must have the flexibility to engage several individual types of targets during one mission. Budget constraints no longer allow for the fielding of specific weapons for each type of battlefield target. As a result, we need to develop weapons that have the flexibility to adapt to

changing mission requirements. These changing requirements include an ability to engage a vast array of target types as well as the ability to produce a varied spectrum of effects on those targets. A third characteristic of future CAS munitions will be interoperability between large numbers of delivery vehicle types and different military services or nations. Compact and lightweight construction translates to increased delivery platform performance as measured in range, number of weapons carried, loiter time, maneuverability, and survivability. A final CAS weapon requirement is an ability to lower threat exposure to the carriage platform during the delivery sequence. CAS becomes truly viable only if we can ensure an acceptable risk-to-gain ratio during its execution. Designing stand-off munitions that do not expose delivery vehicles to high-threat environments is one way to increase survivability.

The US military is developing two systems to provide a CAS capability in the future: the joint direct attack munition (JDAM) and the joint standoff weapon (JSOW). JDAM is a low-cost, GPS-aided, inertial guidance kit that is attachable to unguided Mk. 83 (1,000-lb.), Mk. 84 (2,000-lb.), BLU-109, and I-2000 deep penetrating bombs.[30] This jointly developed munition attempts to increase the accuracy of weapons types currently in inventory without increasing disproportionately their overall cost. JDAM uses a guided-bomb tail kit to provide GPS updates to a dumb Mk-80-series bomb to increase the bomb's accuracy during the delivery phase of its use. Estimated JDAM accuracy falls in the 10-to-12 meter range, making it an "accurate weapon" but not a precision weapon.[31] Weapons such as laser-guided bombs are considered to be precision munitions because they produce a very small if not zero circular error probability (CEP). JDAM will be much more cost-effective than true precision munitions against targets that do not demand a zero CEP. JDAM demonstrates an improvement in desired target effects and interservice interoperability over current Mk-80-series munitions. This is the beginning of the trend toward the future weapon characteristics discussed earlier.

JSOW consists of various submunitions carried on a nonpowered, aerodynamically efficient airframe. This frame is constructed of composite and aluminum materials with nonfolding fixed and moveable tail surfaces and folding wings. Submunitions carried include the BLU-97A/B combined-effects submunition, the BLU-108 sensor fused array submunitions, and a preplanned product improvement unitary warhead.[32] The weapon's design served to further meet the necessary characteristics of future CAS munitions by addressing the flexibility, desired effect, interoperability, and threat exposure issues.

2025 CAS must be conducted in a cost-effective and survivable manner. Planners and operators must exercise caution before exposing a multimillion-dollar aircraft to a high-threat level for any sort of mission. This threat exposure is necessary in today's environment because the delivery platform/munition combination is not capable of delivering weapons in a manner that shields the delivery platform to a sufficient degree.

There are three approaches to addressing this problem. The first is to develop weapons delivery platforms that are inherently less vulnerable to the fielded threat. An example of this is the current emphasis on stealth technology and self-protection systems. The second is to develop munitions deliverable from outside the lethality ring of the fielded threats. Examples of this are weapons such as the Tomahawk cruise missile and other stand-off munitions. The third approach is a combination of the two.

The three approaches described above cover a wide spectrum of cost, with the first option representing a very high price tag for the delivery vehicle and the second representing a high cost per weapon. There are inherent advantages and disadvantages to both extremes. As the price of the munition or delivery platform increases, the number obtainable with a fixed budget decreases. Senior leaders must wrestle with classic quantity-versus quality decisions. It is important to remember, however, that the combination of weapons delivery platforms and munitions must be of a quality that is sufficient to have a high probability of accomplishing the mission but also of a quantity that is sufficient to be able to take out the volume of anticipated targets. Too few high quality weapons systems are as disadvantageous as an unlimited supply of ineffective low-quality systems. The purpose here is to identify weapon characteristics in 2025 that strike the necessary balance between the quality and quantity extremes.

Keeping the above in mind aids in identifying several key aspects of 2025 munitions. Weapons for 2025 permit the assignment of target and desired effect data to the weapon while onboard the platform or after release. As a result, weapons allow onboard or in-flight reconfiguration of their effect mechanism. To make the weapon truly effective requires flexible guidance options and delivery methods. Developing a fairly high degree of quality and capability into each weapon while maintaining a very high level of to engage a wide array of targets and employment scenarios is extremely important.

Although a high level of capability tends to increase the cost of each weapon, the high degree of flexibility achieved allows the same results with a much lower overall inventory of munitions. This allows additional savings in areas such as logistics, storage, transportation, training, and maintenance. As a result,

these savings can defray increases in the cost of weapons due to their increased sophistication and capability, thereby allowing more weapons to be procured. The end result is an overall decrease in the quantity and types of weapons but an increase in their overall capability and utility. This translates to increased survivability of the delivery platform, thereby reducing the number of delivery platforms required in the force. In essence, a smaller but more capable force structure. The classic example of this reasoning is seen in the combat capability of hundreds of B-17s during World War II (WW II) compared to the effects of just one F-117 carrying two bombs in the Persian Gulf War. These two weapon systems produced similar effects on their targets.

Achieving the anticipated gains in weapon capability requires advancements in computer, guidance, and explosive technology. Weapons used in the 2025 CAS environment must overcome two current limitations of today's weapons. First, they must be dispensed from a platform likely to be well away from the battlespace and not in direct view of the target. Since the delivery vehicle may be anywhere in relation to the friendly and enemy positions, future munitions must be accurate enough and reliable enough to dispense with bomb fall line and aircraft run-in restrictions. Second, they must be able to identify, track, and achieve desired effects on a variety of target types autonomously. Guidance packages and seeker systems permit targeting the weapon or changing targets while onboard the delivery platform, after release, or late in the terminal guidance phase. Battlenet targeting information includes specific target characteristics such as exposed armor aligned linearly north to south in a 50 X 300-meter array and a specific weapon assigned to the target. Each munition provides its own identity to the delivery platform, hence to the battlenet, so that each munition may be independently targeted.

Active or passive seekers will be onboard-selectable. An active seeker illuminates the target by a multispectral source such as radar, laser, or optics. Active illumination of the target by the weapon requires guidance to the target from onboard navigation systems or steering from the battlenet until the weapon reaches acquisition range and begins terminal phase guidance. This guidance could include an on-munition target CID interrogator, or a system able to read the labels installed on enemy vehicles outlined in the previous section. Longer range and endurance CAS weapons require a target recognition system capable of identifying target signatures and characteristics. Passive guidance requires the battlenet to guide the weapon through all phases of flight into contact with the target. Since the battlenet already identified and tracked the target, the system

could issue precision guidance instructions to the weapon. Passive guidance includes the ability of the weapon to read and identify multispectral signatures, either independently or in conjunction with the battlenet, then home in on the source of the signatures. Weapon susceptibility to countermeasures is on par with the battlenet. If necessary, the weapon cross-checks target location with the battlenet to resolve inaccuracies. Weapon guidance system degradation should be graceful and nonlethal. A malfunctioning guidance package requests and receives assistance from the battlenet, a manned platform, or a ground controller. If a malfunction prevents the weapon from accurately recognizing or tracking a target, the weapon deactivates and/or initiates low-order self destruction before impact.

The munitions of the future will be lightweight and multipurpose. Inflight conversion from a unitary warhead to submunitions or mines allows inherent targeting flexibility. In addition, battlenet input and onboard target recognition features allow flexible yields from the unitary warhead. Dual use of the stored energy material as an explosive or propellant would allow tactical trades of energy expenditure against the target or increased stand-off ranges. Submunitions exhibit independent target acquisition capabilities. A nonexplosive kill mechanism such as hypervelocity darts reduce the complexity of the weapons package but they still require a guidance package to get them into position to accelerate into the target. The capability must exist to target individual enemy troops in close proximity to friendly forces and incapacitate or kill them without exposing friendly troops to the weapons effects. Steerable flechettes or directed-energy weapons fired from overhead uninhabited platforms could have this effect.

CAS in urban environments or during peacekeeping missions requires the option of using nonlethal weapons. Acoustic signals, microwaves, sticky foam, or mood-altering pheromones could be dispensed. The caveat here is that friendly troops must have the inherent ability to resist the effects of these weapons because they may not know the type of weapon being used, hence may not have time to prepare. Special ear plugs, nose filters, or uniforms become standard equipment for this type of engagement. *New World Vistas* envisions an autonomous miniature munition (AMM) which is a small (<100 pounds), highly effective unitary munition providing a force-multiplying capability over a wide range of air-to-surface tasks.[33] Perhaps the AMM offers suitable nonlethal effects packages for use in these special environments. However, getting the AMM to be truly effective requires rapid progression in ATR, adaptive lethality, onboard guidance, and maneuvering packages.[34]

Concept of Operations. Modularity in the build up of flexible munitions (FM) results in a customized weapon tailored to a specific target, or similar subset of targets. A truly effective FM uses a hybrid that material provides a range of released energy effects on a target and which doubles as a propulsive source for stand-off applications. Modularity can also reduce cost by allowing a specific sensor, guidance, and stand-off mechanism to be used as tasked by the battlenet. This reduces system multicapability redundancies that frequently drive up costs.

A self-contained FM production system (fig. 3-4) could be used to rapidly respond to battlenet requests for customized weapons. By producing the weapons "just-in-time," storage and manual assembly of weapons could by eliminated.

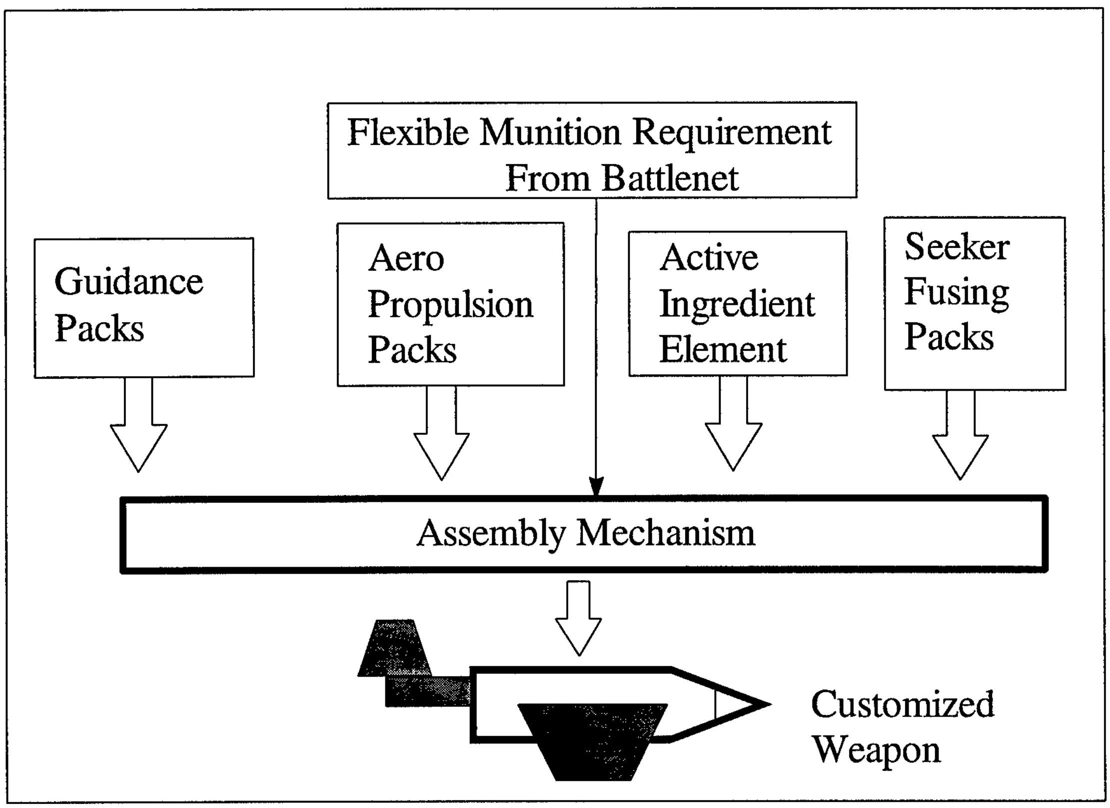

Figure 3-4. Flexible Munition Production Pallet and Subsystem

Location of the system could vary from internal carriage in larger aircraft when their use is warranted, to flightline or forward operating base use for smaller aircraft (fig. 3-5). In large aircraft, the greatest flexibility would be realized since little to no weapons carriage structure would be required. The weapon

would simply be produced and expelled in a continuous process. In smaller aircraft, a universal carriage mechanism is desired. In either case, support for the system would be replenishment of high-use subcomponents.

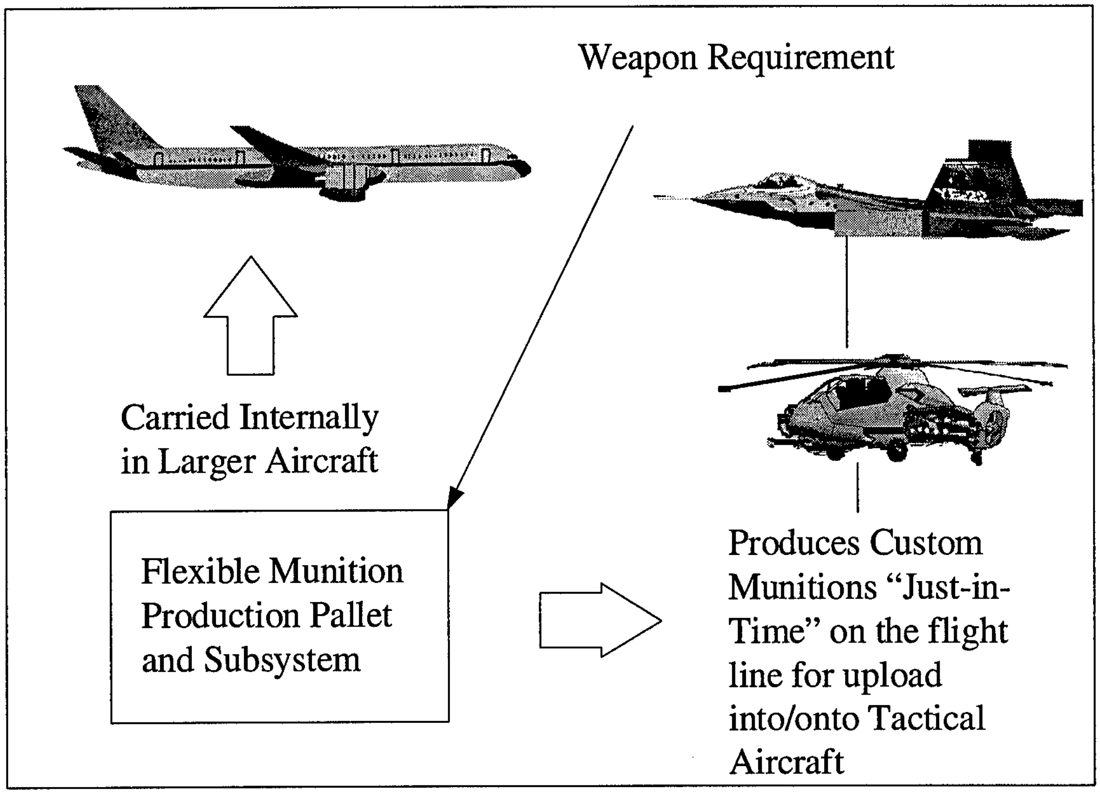

Figure 3-5. FM Multiple Uses

In summary, the battlespace of 2025 may be very different from that of today. However, the four subtasks of air-to-ground attack will remain. The goal of any system will be timely, and precise firepower. Reduction of effort and simplification of combat tasks for the human components during high stress will reduce the "fog of war" and allow the human to better deal with the results of "friction."

[1] USAF Scientific Advisory Board, *New World Vistas: Air and Space Power for the 21st Century,* summary volume (Washington, D.C.: USAF Scientific Advisory Board, 15 December 1995), *5.*

[2] Ibid.

[3] Ibid.

[4] "Force XXI America's Army in the 21st Century," *Army Focus,* September 1994, 13.

[5] Ibid., 40.

[6] 2025 Operations Analysis Team interview, Air University, March 14, 1996.

[7] *New World Vistas,* summary volume, 23.

[8] Vincent Kiernan, "The Eyes That Never Sleep," *New Scientist* 148, no. 2002 (4 November 1995): 510.

[9] David A. Fulghum, "Long Range Sensor Offers Options," *Aviation Week & Space Technology* 139, no. 2 (12 July 1993): 23.

[10] *New World Vistas,* summary volume, 22.

[11] **2025** Concept, No. 901093, "Continuous Area Surveillance and Denial," **2025** Concepts Database, (Maxwell AFB, Ala.: Air War College/**2025**, 1996).

[12] *New World Vistas,* (unpublished draft, the sensor volume), i.

[13] *New World Vistas,* (unpublished draft, the attack volume), x.

[14] Ibid., 40.

[15] **2025**, Concept, no. 901175, "Holographic Image Projector," **2025** Concepts Database (Maxwell AFB, Ala.: Air War College/**2025**, 1996).

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[17] *New World Vistas,* (unpublished draft, the sensor volume), ix.

[18] "New Electronic Device Developed to Prevent Friendly Fire Incidents," *Defense Electronics* 27, no. 3 (3 March 1995): 12.

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[20] Scott R. Gourley, "U.S. Army Warriors: 21st Century Equipment for 21st Century Missions," *Defense Electronics* 27, no. 1 (January 1995): 14.

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[23] Micheal A. Dornheim, "New Sensors Show Two Paths to Reconnaissance," *Aviation Week & Space Technology* 143, no. 2 (10 July 1995): 48.

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[25] **2025** Concept, no. 900913 " Virtual Battlefield Assessment Integrator," **2025** Concepts Database (Maxwell AFB Ala.: Air War College/**2025**, 1996).

[26] Richard Aboulafia, "A Bomber Force Unrivaled.," *Aviation Week & Space Technology* 144, no. 2 (8 January 1996): 17.

[27] David A. Fulghum, "ARPA Explores Unmanned Combat Aircraft Designs," *Aviation Week and Space Technology* 144, no. 9 (26 February 1996): 23-25.

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[29] James C. Dunn and Donald L. Wiess, "B-2A Flight Test Progress Report" *Society of Experimental Test Pilots Symposium Proceedings* 1995, 17-33.

[30] David A. Fulghum, "Pentagon Cuts Field of JDAM Candidates," *Aviation Week & Space Technology* 140, no. 15 (18 April 1994): 22.

[31] Ibid.

[32] Mark G. Chauret, ed., *Air Combat Command Operational Concept for the Joint Standoff Weapon (JSOW)*, Draft, 28 March 1994, 4-5.

[33] *New World Vistas,* (unpublished draft, the munitions volume), 10.

[34] *New World Vistas,* (unpublished draft, the munitions volume), 11.

Chapter 4

Concept of Operations

The underlying basis for this entire concept is the battlenet. It must exist either in physical form or as an assembly of computational elements in cyberspace. Access to and modification of individually desired architectures must occur at the first indication of need. Ideally, configuration and access requirements would be preplanned and "on the shelf" at the joint planning cells. Any service makes airpower assets (aircraft, weapons and personnel) available to the CINC. The need for tactical mission planning is small and the need for weaponeering is negligible. Aircraft loaded with FMs await a signal from the battlenet to launch. Platforms receive instructions (via datalink commands) to either fly to a point (to await CAS-type assignment) and hold, or to fly to a point and relegate commit authority to the battlenet. Weapons release occurs to engage targets enroute or upon reaching a turnaround point. The battlenet assigns a weapon to a target, then passes FM configuration data to the individual weapon via the carriage platform. The platform releases individual weapons or groups of weapons during various portions of the flight. The same aircraft may drop one or two weapons while crossing an area with troops in contact, drop all but a few against strategic targets, and drop its remainder against an emerging target during its return to reload.

Employment

To initiate a CAS mission, the requester first contacts the battlenet and provides proper authentication. After providing target data and desired effect to the battlenet, controllers receive a target correlation confirmation, proposed TOT, and a request for release authorization. The controller, perhaps someone many leagues from the target, confirms this information, authorizes weapon release, and awaits target engagement.

The controller would either personally evaluate target condition after the attack or receive that information from the battlenet, which could use multiple sources of data to better determine residual effectiveness of the target. Figure 4-1 depicts this process. For interdiction or strategic attack, the same process could occur with the controller being replaced by anyone, anywhere, with access to the battlenet as authorized by the JFACC.

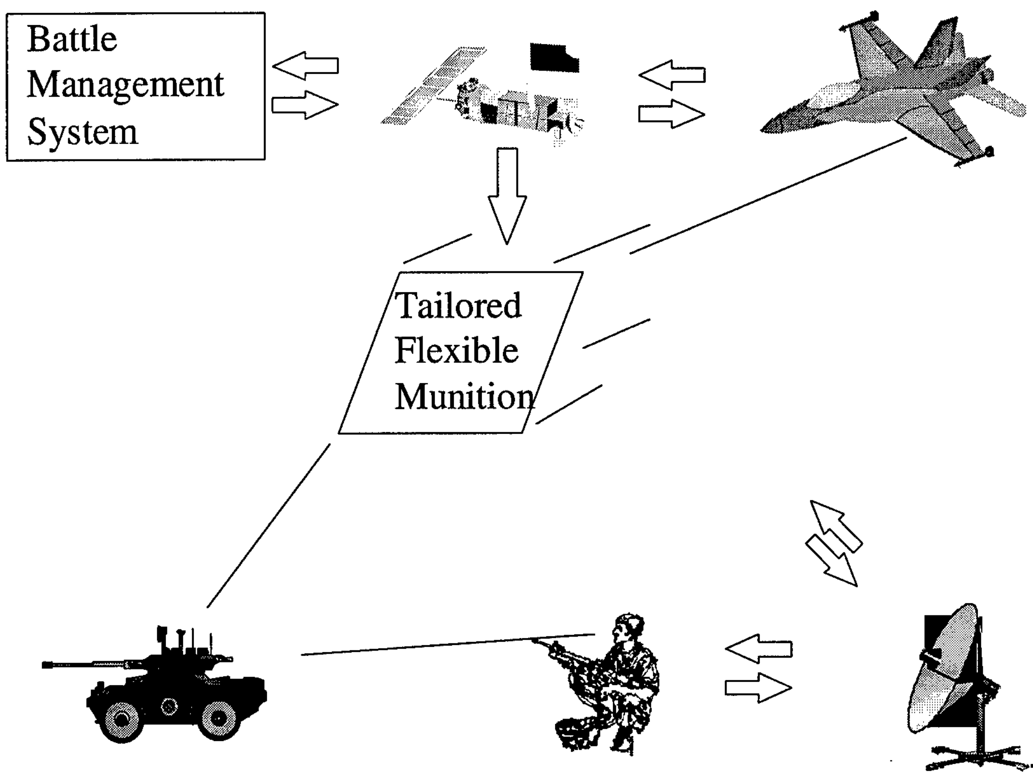

Figure 4-1. Battlenet

Communications, Logistics, and Personnel Requirements

Current communications methods use multiple bands of the RF spectrum. This makes directional detection of transmissions fairly easy. Using LPI techniques helps minimize the possibility of detection. Using other spectral regimes offers security and redundancy. Burst transmissions use the time domain for similar benefits.

Use of tracking software allows business and industry to monitor the transshipment status of materials. Satellite tracking of shipment and inventory control transponders will provide similar capability on a global scale. Logistics tracking subsystems of the battlenet provide additional information to battle managers, with AI-monitored flags available to warn of impending shortages.

Personnel management tasks in 2025 take on even more significance due to lower overall manning levels. Training must be continuous as new applications of technology take hold. As reliance on technology increases, the ability to gracefully degrade to less automated modes becomes very important. Commanders must ensure that personnel do not lose the capability to revert to manual operations if the system becomes degraded. If the battlenet breaks, do the troops know how to call in air support?

Strategically, reduction of the human risk element in many combat environments may increase the willingness of political leadership to employ combat power. The effects of the dehumanization and mechanization of warfare will carry profound philosophical implications. The "push-button" warriors forecast in the seventies became the "video" warriors forecast in the early nineties. By 2025, technically motivated remote control advocates may cause a shift in perception regarding the use of deadly force. The images and realities regarding the inhuman nature of any form of warfare may be the first elements of information filtered from the battlenet. Impersonal employment of death-producing effects, from safe and cozy command centers by those not willing to accept personal risk, fundamentally changes the face of conflict. The moral implications are immense.

Countermeasures

As targeting, C^4I, weapons, and delivery systems evolve, the US military must expect improvements in enemy countermeasures to these systems. Some of the countermeasure methods, such as destruction, deception, jamming, and intrusion, overlap into several of the functional task areas. Negating the effects of the countermeasures may require different methods, depending on the functional area affected.

Central to the concept of CAS in 2025 is a battlenet for data input, information management, targeting, and command and control. A decentralized battlenet keeps critical nodes to a minimum, that will not prevent a sophisticated enemy from targeting the net. Severing the input sources from the processing units involves

blocking data transmissions, cutting communications uplinks, or electronically separating the data source from the data processor and information from the receiver. Therefore, the system must be resilient enough to withstand these efforts. The battlenet must accept a variety of input methods; for example, a controller with a voice radio should be able to call in target information to the battlenet. The system accepts and converts the spoken words into digitized information used by the battlenet.

If an enemy developed the ability to produce false targets, he could pose several different levels of threat. First, the volume of target information may overwhelm the battlenet itself. Second, the target indications could cause human battlespace commanders to commit weapons to invalid targets. Electronically placing real targets in the wrong location is a technology that is readily available now. If an enemy creates false targets and the battlenet recognizes them as being false, then his forces would be immune from attack if he physically or electronically disguises vehicles and personnel to resemble the false targets. We will not be alone in the technology race. A likely scenario provides a peer competitor access to the same weapons and technology we have. Security of information-based systems must remain a top priority.

Long-range enemy UAVs patrol deep in our territory looking for ours. Air-to-air and surface-to-air weapons systems will inevitably become more sophisticated in their ability to detect, track, and shoot down aerial and even space platforms. This indicates either a need for us to develop small numbers of well-defended platforms with resultant complexity or, perhaps, larger numbers of simple and redundant platforms networked so that losses do not critically affect operations. An effective method of preventing CID poses serious threats to our ability to conduct CAS operations. Compromise of critical capabilities and subsequent reproduction of CID signals could be devastating. Future CID systems should avoid using single-mode interrogation techniques.

The capability for graceful degradation must be built into any system to permit the battlespace commander to authorize weapons release based on targets input by sources outside the battlenet; for example, the forward controllers on the ground. If a threat successfully falsifies its position or prevents detection by our sensors, then command and control could reduce to the forward controller with a pair of binoculars and a radio calling in air strikes.

Perhaps the worst thing the enemy can do to our system is to cause errors in the determination of his location. In 2025, weapons will be small and sophisticated. They travel to targets using offboard systems,

onboard guidance, or a combination of the two for midcourse and terminal guidance. A reduction in the size of weapons in 2025, plus the possible high cost of placing terminal sensors on each munition, creates an argument for placing command guidance packages on some weapons. These weapons remain under the control of the battlenet and receive offboard guidance all the way to impact. Therefore, if the battlenet has incorrect information on the target location by even a few meters, the likelihood of successful target engagement decreases.

Enemy vehicles of the future-- and even personnel-- may carry a close-in self-defense system incorporating a target detector, tracker, and kill mechanism. Once our weapon succeeded in finding its way to the target, it would still run the risk of being intercepted and negated in the last few hundred meters. Our weapons must be too quick, too agile, too smart, or a combination of all three. By smart, the weapon must be able to sense and react to outputs from the target such as lasers, radar, particle beams, or projectiles. Reaction consists of maneuvering by the weapon, closing its eyes for a short time, deflecting or disrupting the enemy's defensive weapons, or targeting the source of the enemy's defensive system.

In any event, the continuous cycle of countermeasure and counter-countermeasure is prohibitively expensive. In fiscally limited environments, the risk exists that threat reactions to system development and deployment are ignored. The easiest method of preventing countermeasure development is to highly classify the newly developed capability. But this carries an increased price tag in security costs, and is in fact a tenuous solution. Compromise of any capability, especially in an information intense era is almost inevitable.

The best method for ensuring war-fighting superiority is to have an acquisition strategy that includes preplanned program improvements and that tests the system in a realistic operational environment. Testing acquired threat systems against ours demonstrates system strengths and weaknesses. The increased use of modeling and simulation runs the risk of missing a hidden threat capability or, just as bad, overestimating a threat capability and wasting precious resources to counter a nonissue.

Joint, Coalition, or Non-Combatant Operations

Systems proposed in this paper must be available to all US forces. Service-unique requirements must not result in reduced joint usage. Various forms of US systems should be made available to our coalition allies. Transparent sophistication will allow for rapid incorporation into any country's forces.

Nonlethal forms of air-delivered weaponry will have direct application in civil disturbances or operations-other-than-war (OOTW). The ability for the battle manager to rapidly apply various levels of precise power to a complicated target area will provide for a much larger range of risk-management options.

Chapter 5

Investigative Recommendations

To improve close air support in 2025, the Department of Defense should focus its research and investigation on the three main areas listed in table 1: battlenet, weapons, and aircraft.

Table 1

Recommended Research Areas

Area for Research	Component
Battlenet	Combat Identification
	Controls and Displays
	Sensors
	Datalinks
	Artificial Intelligence
Weapons	Stand-off Range
	Terminal Guidance
	Non Lethal
	Flexible Configuration
Aircraft	Uninhabited Aerospace Vehicles
	Situational Awareness
	Performance/Survivability

The information revolution comes to CAS in the form of the battlenet, a network of sensors, computers, communications, and displays. The most important element for development within the battlenet is a reliable combat identification system. The lack of CID and the fear of fratricide make CAS extremely difficult, and training intensive, and they generate employment tactics not conducive to aircraft survival.

Modeling the battle and manipulating information-require new controls and displays. Hardware for displays being developed in the civilian sector will probably be sufficient for military needs. However, the mission-essential software may not be. There are some fundamental differences between the military and civilian computer-operating environments. Speed and clarity are important in both environments. Five

minutes to achieve a completely accurate solution may be quite reasonable to a civilian but intolerable in combat, where an 80 percent solution is acceptable if given in five milliseconds. Most civil applications allow for the operator to focus undivided attention on the data presentation. The combatant operating in a rugged environment under great stress faces life-threatening distracters. He or she will not have time to call up a file manager while sitting comfortably at a desk out of the line of fire. Combat cannot tolerate time spent searching through different pages or levels of software for enough information to formulate an overall picture. There is no such thing as a combat file manager.

Data cannot be dumped on warriors; it must be converted to information, then pushed to the combatants this allowing them flexibility in determining quantity and format. Customized displays on a variety of mediums are absolutely essential to the war fighters. Programs must pursue the lessons learned from related works and projects when designing controls and displays. Keep one eye focused on maintaining flexibility. This is especially true in a world where electronic obsolescence can occur in a few months while new weapons are introduced every few years and aircraft are expected to last decades.

The B-2 program managers elected not to transfer the lessons learned from previous aircraft developments in developing a new software architecture. A rigid, constrained, focus on a single mission unnecessarily increased aircrew workload to the point that it was rated marginally acceptable before the demanding or complex evaluations could be flown.[1] Experienced organizations designing from scratch, following old paradigms, or new inexperienced organizations may be prone to offer what works in an office, machine, process, or game as a solution to the military's needs. Meeting military demands requires robust testing, demonstrated flexibility, and expandability for all types of systems. Continuing progress in the development of artificial intelligence and computer processing power by the civil sector should provide the requisite technology to comply with the military's unique needs to convert data to easily accessible information.

Our senior leadership's vision of the future must motivate substantial investment in reconnaissance and surveillance sensors and platforms. In the future, the multitude of sensors and platforms must be melded into an overarching architecture that supports the battlenet concept. As the battlenet generates improved situational awareness for all echelons of command, the demand for additional information increases.

Therefore, the system of sensors providing data to the battlenet must permit room for rapid growth and expansion.

The string, composed of communications and datalinks, ties the pieces of the battlenet together. Security, speed, and bandwidth require ongoing research and development.

Integrating improved weapon systems into the battlenet will vastly increase the capability of US forces to accomplish CAS. By 2025, all combat aircraft gain the ability to accomplish this mission 24 hours-a-day, regardless of the weather. Increased standoff range, quantum improvements in terminal guidance, sensing, and fusing enhance weapon effectiveness. Targeting flexibility and nonlethal capabilities add new dimensions to CAS operations. In the future, the air tasking order (ATO) may task individual weapons vice actual aircraft.

The current evolution of aircraft is proceeding on the right track. The Department of Defense (DOD) is correctly placing emphasis on developing uninhabited and remotely piloted vehicles. These are the weapons platforms of the future. We will be able to find, identify, and attack targets at lower risk and ultimately lower cost via these platforms. Manned aircraft, however, will not be eliminated by 2025. Accordingly, we should continue to pursue improvements in aircraft performance and stealthiness. These improvements, however, are not the only means of enhancing combat effectiveness. The construction of the battlenet, weapons advancements, and better automation will greatly improve and prolong aircraft combat effectiveness. Improvements that enhance situational awareness will provide the maximum return in combat capability.

The acquisition process is the foundation for much of this improvement. We need an improved cost-effective process that fields technology quickly and supports oversight requirements. The civilian sector aids this process by accomplishing most of the initial research and development. Unfortunately, new developments also aid our enemies, hence we must be able to exploit civil technologies before our adversaries do.

Current acquisition methods are acknowledged to be unwieldy and unnecessarily restrictive. In the emerging era of extremely rapid technology growth, the acquisition system must accelerate to maximize the benefits of new capabilities. The phenomenon of "obsolescence while in development" is a very real hazard. The process also requires continued reform in the face of shrinking defense dollars and the defense industrial base. Using concurrent developmental and operational test processes reduces time and funding

requirements. Detailed modeling and simulation techniques can accurately predict system performance. Operational suitability of future systems will be much easier to test due to the inherent reliability of electronic systems.

A strategic development plan and common architecture must be agreed upon at the earliest planning stages to provide a framework on which to construct independent elements. Concurrent development of subcomponents must occur to shorten the acquisition cycle.

Service parochiality and fights for scarce fiscal resources must be avoided at all levels. Joint procurement processes must continue to be required at every possible opportunity. However, we arrive at the battle in 2025, we know there are austere funding environments enroute. Maintenance of the US military's supremacy in the future will require constant improvement in both technologies and practices. A constant maximum effort must be made by every member of the profession of arms to continually optimize the vast capability of this force, regardless of uniform color, and blind as to which service operates which system. To do less shirks our sworn duty.

Notes

[1] Col James C. Dunn and Donald L. Wiess, "B-2A Flight Test Progress Report" *Society of Experimental Test Pilots Symposium Proceedings*, 1995, 17-33.

Appendix A

Close Air Support Definitions

Close Air Support enjoys a similar definition in each branch of the service. These definitions came from several sources and were cross-referenced. This appendix presents the definitions in the following format:

Branch Of Service

Source of information

Reference where source discovered information

Text of information

USAF

Air Force Manual 1-1 Volume II *Basic Aerospace Doctrine of the USAF* March 1992.

Joint Pub 1-02

Air action against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces.

US Army FM 100-20, July 1943

Air participation in the combined effort of the air and ground forces, in the battle, to gain objectives in the immediate front of these ground forces.

Joint Force Air Component Commander (JFACC) Primer 2nd ed., Feb. 1994.

Joint Pub 1-02

Close support -- action against targets or objectives sufficiently near the supported force as to require detailed integration or coordination of the supporting unit.

Close Air Support: Supported Commander: JFLCC

CAS Targeting: JFLCC

Coord Air: JFACC

Graphically CAS is depicted as air to surface operations between the Forward Line of Troops (FLOT) and the Fire Support Coordination Line (FSCL)

The United States Air Force, A Dictionary edited by Watson and Watson Garland Publishing, Inc. New York and London 1992.

Department of Defense, Department of the Air Force. *The United States Air Force Dictionary.* Edited by Woodford Agee Heflin. Montgomery Ala.: Air University Press, 1956.

Poyer, David *The Med.* New York: St. Martin's Press, 1988.

Close Air Support (CAS) is action against enemy targets that are close to friendly forces. It requires the detailed integration of each air mission with the fire and movement of the enemy forces. Close air support is requested and approved by the support unit commander, and is controlled by the forward air controller.

Department of Defense, Department of the Air Force. *Air Force Pamphlet 50-34, Training: Promotion Fitness Examination Study Guide.* vol 1. Washington, D.C.: Headquarters US Air Force, 1990.

Department of Defense, Department of the Air Force. *The United States Air Force Dictionary.* Edited by Woodford Agee Heflin. Montgomery Ala.: Air University Press, 1956

Close Air Support Missions support land operations by attacking hostile targets close to friendly surface forces. Close air support can support offensive, counteroffensive, and defensive surface force operations with preplanned or immediate attacks. All preplanned and immediate close air support missions require access to the battlefield, timely intelligence information, and accurate weapons delivery. Close air support enhances land force operations by providing the capability to deliver a wide range of weapons and massed firepower at decisive points. It can surprise the enemy, create opportunities for the maneuver or advance of friendly forces through shock action and concentrated attacks, protect the flanks of friendly forces, blunt enemy offensives, and protect the rear of land forces during retrograde operations.

JOINT/MARINES

Joint Pub 3-0 Doctrine for Joint Operations 1 February 1995.

Joint Pub 1-02

Air action by fixed and rotary wing aircraft against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces. Also called CAS.

ARMY

United States Army, A Dictionary edited by Peter Tsouras, Garland Publishing,; Inc. New York & London 1991.

Department of Defense, US Army *Air Defense Artillery Deployment: Chaparral/Vulcan/Stinger.* FM 44-3. Washington, D.C.: Headquarters, Department of the Army.

Attack Helicopter Operations. FM 17-50. 1984

Operational Terms and Symbols. FM 101-5-1. 1985

USA/USAF Doctrine for Joint Airborne and Tactical Airlift Operations. FM 100-27, 1985.

Close Air Support is air action against enemy targets that are located close to friendly forces. Thus, the detailed integration of each air mission with the fire and movement of the enemy forces is required. Close air support is requested and approved by the support unit commander, and is controlled by the forward air controller.

Department of Defense, US Army. *Operations.* FM 100-5. Washington, D.C.: Headquarters, Department of the Army, 1986.

USA/USAF Doctrine for Joint Airborne and Tactical Airlift Operations. FM 100-27, 1985.

Close Air Support Missions support land operations by attacking hostile targets in close proximity to friendly surface forces. Close air support can support offensive, counteroffensive, and defensive surface force operations with preplanned or immediate attacks. All preplanned and immediate close air support missions require access to the battlefield, timely intelligence, information, and accurate weapons delivery.

Close air support enhances land force operations by providing the capability to deliver a wide range of weapons and massed firepower at decisive points. It can surprise the enemy, create opportunities for the maneuver or advance of friendly forces through shock action and concentrated attacks, protect the flanks of friendly forces, blunt enemy offensives, and protect the rear of land forces during retrograde operations.

FM 100-26 Chapter 3, Air Support Operations

Close air support is air attacks against hostile targets that are in proximity to friendly ground forces and that require detailed integration of each air mission with the fire and movement of those forces. The fixed wing CAS strikes are controlled by an element of the tactical air control system (TACS) operating with the supported maneuver unit. This element is responsive to the needs of the commander of the ground unit.

NAVY

The United States Navy, A Dictionary edited by Bruce W. Watson, Garland Publishing, Inc. New York & London, 1991.

Department of Defense, Joint Chiefs of Staff, *Department of Defense Dictionary of Military and Related Terms,* Washington, D.C.: 1985

DOD, US Naval Education and Training Command, *Air Traffic Controller 1&C* NAVEDTRA 10368-F2, Washington, D.C.: 1983

Air Traffic Controller 3&2. James T. Pruett ed. NAVEDTRA 10367-G. Washington, D.C.: 1983

Seabee Combat Handbook. Patrick J. Essinger, ed. NAVEDTRA 10479-C2. Washington, D.C.: 1985

Close Air Support is air action against hostile targets that are close to friendly forces and that require detailed integration of each air mission with the fire and movement of those forces.

Appendix B

Close Air Support Description

All the services use the same joint definition of CAS. CAS gives the ground force commander the ability to engage the enemy with the combined arms of ground and air forces to gain synergistic effects over the battlefield and its targets. To accomplish this integration, the ground commander gains access to the air component's planning and execution process. Specialized communication nets tie these leaders into the normal ATO process and also provide the ability to get crisis response on short notice requests.

All US armed forces doctrinally conduct CAS very similarly, although the CAS joint publication is currently being written. CAS is centrally controlled and decentrally executed. The higher unit commander approves missions and then the FAC and delivery aircraft actually controls final execution. This allows the Air Component Commander to allocate his air resources in compliance with the joint force commander (JFC) direction. To accomplish this, an extensive command and control (C^2) network has to be used. CAS differs from air interdiction by its proximity to friendly ground forces and the need for detailed integration of each mission with the fire and maneuver of those forces. Due to concern over fratricide, constraints have been put in place to protect ground forces (mark and clearance to drop). These constraints limit tactical flexibility of the delivery aircraft.

Currently, CAS can be divided into the following C^2 nodes:

System	Current Agency
1. Terminal Controller	FAC (ground or airborne)
2. Ground C^2 System	Fire Support Coordination Center (FSCC)
3. Aviation C^2 System	Tactical Air Command Center/ Tactical Air Control Center(TACC)/ Direct Air Support Center (DASC)
4. Delivery Platform/Weapon	Aircraft

The terminal controller is a forward air controller (FAC) whose responsibility is to safely control CAS aircraft ordnance delivery. The FSCC reviews allocation of fixed-wing resources and subordinate requests for CAS support. The FSCC also plans for and coordinates future CAS requirements. The senior-level FSCC or equivalent presents a prioritized listing of requirements to the TACC. The TACC provides CAS sorties to Army forces based on the apportionment decision of the JFC while the DASC provides for fast reaction capability for immediate CAS requests. Aircrews receive the mission from either the ATO or the TACC. Requirements for effective CAS include air superiority, suppression of enemy air defenses (SEAD), target marking, favorable weather, flexible control, prompt response, aircrew, and terminal controller proficiency.

Appendix C

CAS Fundamentals

Apportionment/allocation. CAS is only one of the many missions of airpower. The JFC, through the JFACC balances the percentage of sorties among the various missions to achieve the campaign objectives. The JFC chooses this apportionment by using inputs from his various subordinate commanders and comparing the requirements to the availability of air assets. The Omnibus Agreement provides further guidance on the special airpower requirements of the Marine Corps' Marine Air Ground Task Force (MAGTF) concept. The JFACC takes the JFC apportionment decision and allocates the available CAS sorties to ground commanders. If the ground commander exhausts his allocated CAS sorties, he may request additional sorties. Conversely, he returns excess sorties to the JFACC for use on other missions.

Communications. FACs and other agencies pass detailed instructions on short notice to the aircrews. Specialized fire control, tactical air request, and tactical air direction nets are in place to plan, request, coordinate supporting arms, and direct aircraft. UHF and VHF channels are vulnerable to exploitation by the enemy thus creating the potential for the disruption of CAS missions. Immediate missions are especially dependent on voice communication. The FSCCs at all echelons constantly monitor a special parallel communication net for fire support deconfliction and approval. The TACCs and FCCs use a "silence-is-consent" procedure that ensures minimum response time to fire support requests. A standard nine-line brief contains the information to complete a CAS mission.

CAS categories. There are two types of CAS requests: preplanned and immediate. Commanders use preplanned requests for anticipated CAS requirements. They allow detailed mission coordination

and planning by the aircrews. Preplanned missions appear on the ATO and have an actual target, a location, and a target time. Ground commanders submit requests for preplanned CAS missions to FSCCs for evaluation, consolidation, and prioritization. The senior echelon FSCC makes the final consolidation and approves missions consistent with the CAS sortie allocation. The FSCC passes the missions to the TACC for execution Preplanned CAS missions compete with other CAS missions for approval and placement on the ATO. Commanders at the battalion level or below use immediate CAS requests for unanticipated or urgent targets which do not appear on the ATO. FSCCs pass the request to the TACC for consideration. If approved, the TACC forwards the request to the Air Support Operations Center for execution. On immediate CAS missions, aircrews do not complete detailed mission planning and coordination before launching. The JFACC holds some aircraft on CAS alert (ground or air) to respond to immediate requests. The TACC has the option to divert aircraft on other missions.

Normal aircraft procedures. A pilot executing a CAS mission plans and flies a route to a predesignated contact point (CP). The pilot contacts the DASC or designated agency and receives further instructions. Pilots usually contact a FAC for final routing and coordination. Pilots fly CAS missions in a high or reduced surface-to-air threat environment. Aircraft, artillery, or naval gunfire provide SEAD to reduce this threat. After completing the mission, the FAC passes BDA to the pilot who then flies through a return-to-force corridor to deconflict with other aircraft, supporting arms, and air defense engagement zones.

Inflight Briefing procedures. Standard nine-line briefs are the joint format for passing CAS information. The brief includes heading, distance, target description, location, elevation, mark, friendly locations, egress instructions, and TOT. Combined operation briefings include the same information but can use different formats.

Target acquisition. Due to the tactical size, dynamic nature, and the necessity for specific target engagement, target acquisition can be the most difficult step of mission completion. Currently, visual recognition is the most common means of target acquisition.

Aircraft losses. The forward area of the battle area is usually heavily defended by air defense systems. This creates a high probability of aircraft loss or damage. Aircraft delivery parameters, multiple attacks, clearance to drop, and lack of SEAD all contribute to aircraft tactics that significantly increase CAS aircraft vulnerability.

Ordnance. Usually, weaponeers choose the specific ordnance for optimum effect on the target during preflight targeting meetings. CAS aircraft on alert for immediate missions may not be loaded with the best ordnance for the assigned target. As a result, the attack may be less effective than required.

Clearance to drop. Due to the close proximity of friendlies, the FAC clears each individual aircraft to drop ordnance. The FAC visually acquires the aircraft to ensure that it heads for the correct target. If the FAC fails to acquire the aircraft due to night, marginal weather, delivery profile, or small aircraft size, the FAC withholds the clearance. This necessitates multiple passes by the attacking aircraft, which considerably decreases its survivability.

Target marking. Targets are marked to improve visual acquisition. Laser designation and smoke are the most common means used to identify targets.

Weather. Poor weather conditions and night operations severely limit CAS effectiveness. Although the current use of night vision devices and sensor pods increase aircraft capabilities, significant limitations exist in marginal weather.

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